

CLAIMS

I/We claim:

[c1] 1. A method for removing material from a microfeature workpiece, comprising:

contacting a microfeature workpiece with a polishing surface of a polishing medium;

placing the microfeature workpiece in electrical communication with a first electrode and a second electrode, at least one of the electrodes being spaced apart from the microfeature workpiece;

disposing a polishing liquid between the polishing surface and the microfeature workpiece;

moving at least one of the microfeature workpiece and the polishing surface relative to the other;

passing electrical current through the electrodes and the microfeature workpiece to remove material from the microfeature workpiece while the microfeature workpiece contacts the polishing surface; and

passing at least a portion of the polishing liquid through at least one recess in the polishing surface so that a gap in the polishing liquid is located between the microfeature workpiece and a surface of the recess facing toward the microfeature workpiece.

[c2] 2. The method of claim 1 wherein moving at least one of the microfeature workpiece and the polishing surface relative to the other includes rotating the microfeature workpiece.

[c3] 3. The method of claim 1 wherein removing material from the microfeature workpiece includes (a) removing at least a first portion of the material by electrochemical-mechanical polishing and (b) removing no material by

direct electropolishing or removing a second portion less than the first portion by direct electropolishing.

[c4] 4. The method of claim 1 wherein the surface of the recess includes a surface of the at least one electrode, and wherein passing at least a portion of the polishing liquid through the recess includes passing polishing liquid through the recess with the gap in the polishing liquid being located between the surface of the at least one electrode and a surface of the microfeature workpiece facing toward the surface of the at least one electrode.

[c5] 5. The method of claim 1 wherein moving at least one of the microfeature workpiece and the polishing surface includes rotating the microfeature workpiece.

[c6] 6. The method of claim 1 wherein moving at least one of the microfeature workpiece and the polishing surface includes rotating the microfeature workpiece at a rate of from about 10 rpm to about 500 rpm.

[c7] 7. The method of claim 1 wherein moving at least one of the microfeature workpiece and the polishing surface includes rotating the microfeature workpiece at a rate of from about 50 rpm to about 200 rpm.

[c8] 8. The method of claim 1 wherein moving at least one of the microfeature workpiece and the polishing surface includes rotating the microfeature workpiece at a rate of about 100 rpm.

[c9] 9. The method of claim 1 wherein moving at least one of the microfeature workpiece and the polishing surface includes rotating the microfeature workpiece at a rate of about 100 rpm or more.

[c10] 10. The method of claim 1 wherein disposing the polishing liquid includes disposing the polishing liquid at a rate of less than one liter per minute.

[c11] 11. The method of claim 1 wherein flowing at least a portion of the polishing liquid through at least one recess includes flowing at least a portion of the polishing liquid through a recess having a dimension generally normal to the microfeature workpiece of from about 0.5 mm to about ten mm.

[c12] 12. The method of claim 1 wherein flowing at least a portion of the polishing liquid through at least one recess includes flowing at least a portion of the polishing liquid through a recess having a dimension generally normal to the microfeature workpiece of from about two mm to about four mm.

[c13] 13. The method of claim 1 wherein flowing at least a portion of the polishing liquid through at least one recess includes flowing at least a portion of the polishing liquid through a recess having a dimension of about 0.375 inch generally parallel to a surface of the microfeature workpiece in contact with the polishing surface.

[c14] 14. The method of claim 1 wherein disposing a polishing liquid includes disposing a polishing liquid having TMAH.

[c15] 15. The method of claim 1 wherein flowing at least a portion of the polishing liquid through at least one recess includes flowing at least a portion of the polishing liquid through a plurality of intersecting recesses.

[c16] 16. The method of claim 1 wherein contacting a microfeature workpiece with a polishing surface includes contacting a downwardly facing surface of the microfeature workpiece with an upwardly facing polishing surface.

[c17] 17. A method for removing material from a microfeature workpiece, comprising:

contacting a microfeature workpiece with a polishing surface of a polishing medium;

placing the microfeature workpiece in electrical communication with a first electrode and a second electrode, the first and second electrodes being spaced apart from the microfeature workpiece;

disposing a polishing liquid between the polishing surface and the microfeature workpiece;

passing an electrical current from the first electrode through the microfeature workpiece to the second electrode to remove material from the microfeature workpiece while the microfeature workpiece is in contact with the polishing surface;

rotating at least one of the microfeature workpiece and the polishing surface relative to the other; and

passing at least a portion of the polishing liquid through recesses in the polishing surface so that a gap in the polishing liquid is located between the microfeature workpiece and surfaces of the first and second electrodes located in the recesses, the gap providing a discontinuity in the volume of polishing liquid between the surfaces of the first and second electrodes and a surface of the microfeature workpiece facing toward the surfaces of the first and second electrodes.

[c18] 18. The method of claim 17 wherein removing material from the microfeature workpiece includes (a) removing at least a first portion of the material by electrochemical-mechanical polishing and (b) removing no material by direct electropolishing or removing a second portion less than the first portion by direct electropolishing.

[c19] 19. The method of claim 17 wherein moving at least one of the microfeature workpiece and the polishing surface includes rotating the microfeature workpiece at a rate of about 100 rpm.

[c20] 20. The method of claim 17 wherein disposing the polishing liquid includes disposing the polishing liquid at a rate of less than one liter per minute.

[c21] 21. The method of claim 17 wherein passing at least a portion of the polishing liquid through at least one recess includes flowing at least a portion of the polishing liquid through a recess having a dimension generally normal to the microfeature workpiece of from about two mm to about four mm.

[c22] 22. The method of claim 17 wherein disposing a polishing liquid includes disposing a polishing liquid having TMAH.

[c23] 23. The method of claim 17 wherein passing at least a portion of the polishing liquid through recesses includes passing at least a portion of the polishing liquid through a plurality of intersecting recesses.

[c24] 24. The method of claim 17 wherein contacting a microfeature workpiece with a polishing surface includes contacting a downwardly facing surface of the microfeature workpiece with an upwardly facing polishing surface.

[c25] 25. A method for removing material from a microfeature workpiece, comprising:
positioning a surface of a microfeature workpiece in contact with a polishing surface of a polishing pad;
disposing a polishing liquid in contact with the surface of the microfeature workpiece;

passing an electrical current between first and second electrodes, through the polishing liquid and through the surface of the microfeature workpiece, at least one of the first and second electrodes being spaced apart from the microfeature workpiece;
moving at least one of the microfeature workpiece and the polishing surface relative to the other; and
controlling relative amounts of material removed from the microfeature workpiece via electropolishing and via electrochemical-mechanical polishing by controlling an amount of the polishing liquid that is disposed between the microfeature workpiece and the at least one electrode but is not disposed directly between the microfeature workpiece and the polishing surface.

[c26] 26. The method of claim 25 wherein controlling relative amounts of material removed from the microfeature workpiece includes directing at least a portion of the polishing liquid through recesses in the polishing surface so that a gap in the polishing liquid is located between the microfeature workpiece and surfaces of the first and second electrodes located in the recesses, the gap providing a discontinuity in the volume of polishing liquid between the surfaces of the first and second electrodes and a surface of the microfeature workpiece facing toward the surfaces of the first and second electrodes.

[c27] 27. The method of claim 25 wherein controlling relative amounts of material removed from the microfeature workpiece includes (a) removing at least a first portion of the material by electrochemical-mechanical polishing and (b) removing no material by direct electropolishing, or removing a second portion less than the first portion by direct electropolishing.

[c28] 28. The method of claim 25 wherein moving at least one of the microfeature workpiece and the polishing surface includes rotating the microfeature workpiece at a rate of from about 10 rpm to about 100 rpm.

[c29] 29. The method of claim 25 wherein disposing the polishing liquid includes disposing the polishing liquid at a rate of less than one liter per minute.

[c30] 30. The method of claim 25 wherein passing at least a portion of the polishing liquid through at least one recess includes passing at least a portion of the polishing liquid through a recess having a dimension generally normal to the microfeature workpiece of from about two mm to about four mm.

[c31] 31. The method of claim 25 wherein positioning a surface of a microfeature workpiece in contact with a polishing surface includes contacting a downwardly facing surface of the microfeature workpiece with an upwardly facing polishing surface.

[c32] 32. An apparatus for removing material from a microfeature workpiece, comprising:

a support member configured to releasably carry a microfeature workpiece at a polishing position;

first and second electrodes positioned to conduct electrical current to a microfeature workpiece when the microfeature workpiece is carried by the support member, at least one of the electrodes being spaced apart from the microfeature workpiece when the microfeature workpiece is carried by the support member; and

a polishing medium disposed between the at least one electrode and the support member, at least one of the polishing medium and the support member being movable relative to the other, the polishing medium having a polishing surface, the polishing surface having at

least one recess positioned to receive a polishing liquid, the at least one recess having a recess surface facing toward the support member and spaced apart from the polishing surface to allow polishing liquid in the recess to form a gap between the polishing position and the recess surface.

[c33] 33. The apparatus of claim 32, further comprising the microfeature workpiece.

[c34] 34. The apparatus of claim 32, further comprising the polishing liquid.

[c35] 35. The apparatus of claim 32 wherein the at least one recess includes a plurality of intersecting recesses.

[c36] 36. The apparatus of claim 32 wherein the at least one recess includes a plurality of intersecting recesses with first recesses oriented transverse to second recesses.

[c37] 37. The apparatus of claim 32 wherein the first and second electrodes are spaced apart from the microfeature workpiece when the microfeature workpiece is carried by the support member.

[c38] 38. The apparatus of claim 32 wherein the at least one recess has a dimension generally normal to the polishing surface of from about 0.5 mm to about ten mm.

[c39] 39. The apparatus of claim 32 wherein the at least one recess has a dimension generally normal to the polishing surface of from about two mm to about four mm.

[c40] 40. The apparatus of claim 32 wherein the recess surface includes a surface of the at least one electrode.

[c41] 41. The apparatus of claim 32 wherein the polishing surface faces upwardly.

[c42] 42. The apparatus of claim 32, further comprising a source of electrical potential coupled to the first and second electrodes.

[c43] 43. An apparatus for removing material from a microfeature workpiece, comprising:
support means for carrying a microfeature workpiece; and
material removal means for removing material from the microfeature workpiece, the material removal means including a polishing surface and first and second electrodes with at least one of the first and second electrodes being spaced apart from the microfeature workpiece when the support means carries the microfeature workpiece, the material removal means further including control means for controlling relative amounts of material removed from the microfeature workpiece via direct electropolishing and via electrochemical-mechanical polishing by controlling an amount of a polishing liquid that is disposed between the microfeature workpiece and the at least one electrode but is not disposed directly between the microfeature workpiece and the polishing surface.

[c44] 44. The apparatus of claim 43 wherein the material removal means includes a polishing pad having the polishing surface, and wherein the control means includes surfaces forming at least one recess in the polishing surface.

[c45] 45. The apparatus of claim 43 wherein the material removal means includes a polishing pad having the polishing surface, and wherein the control means includes surfaces forming at least one recess in the polishing surface, further wherein the at least one recess exposes a surface of the at least one electrode.

[c46] 46. The apparatus of claim 43 wherein the material removal means includes a polishing pad having the polishing surface, and wherein the control means includes surfaces forming a plurality of intersecting recesses in the polishing surface, further wherein at least some of the recesses expose a surface of the at least one electrode.

[c47] 47. An apparatus for removing material from a microfeature workpiece, comprising:

a support member configured to releasably carry and rotate a microfeature workpiece at a polishing position;

first and second electrodes positioned proximate to the support member to conduct electrical current to a microfeature workpiece when the microfeature workpiece is carried by the support member, the first and second electrodes being spaced apart from the microfeature workpiece when the microfeature workpiece is carried by the support member; and

polishing pad material disposed between the electrodes and the support member, the polishing pad material having a polishing surface with a plurality of first recesses and a plurality of second recesses intersecting the first recesses, the first and second recesses extending through the polishing pad material to expose surfaces of the first and second electrodes that face toward the support member, the first and second recesses being positioned to receive a polishing liquid with the polishing liquid forming a gap between the

polishing position and the surfaces of the first and second electrodes.

[c48] 48. The apparatus of claim 47 wherein the first and second recesses are generally transverse to each other.

[c49] 49. The apparatus of claim 47 wherein the recesses have a depth of from at least two mm to about four mm.